A Novel Electrode design for Efficient Droplet actuation using EWOD

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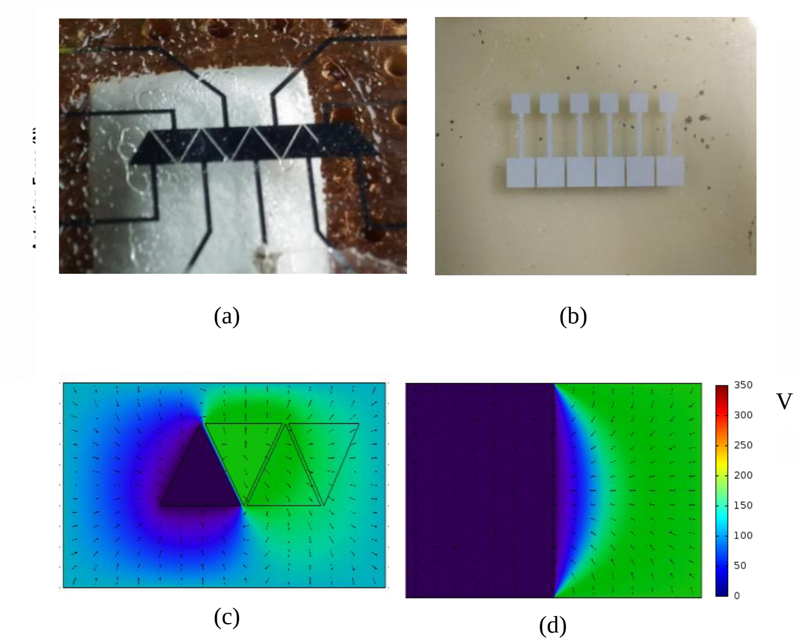
This paper presents the design and fabrication of a coplanar triangular electrode array with significantly enhanced performance as compared to the conventional square shaped electrodes for droplet transport using EWOD.

Droplet actuation by EWOD involves modification of the solid-liquid surface tension by the application of an electric field. The net electrocapillary force acting on the droplet towards the potential *V* activated electrode[1] has been expressed by the well known Young-Lippmann equation. However, on a square electrode, this force remains constant over the entire activated square electrode, along with the length of the contact line during transport. On the contrary, during transportation of the droplet over a coplanar triangular electrode of dimension *L*, the effective contact line length changes when the droplet remains in the middle of the activated electrode (i.e. the median of the triangle) but remains the same during the entry and exit (i.e. side of the equilateral triangle, *L*) of the droplet over the activated electrode. The total electrocapillary force for droplet displacement over coplanar triangular electrode can be expressed as,

$$F_T = (2L + \frac{\sqrt{3}}{2}L)\gamma_{LV}(\cos\theta_V - \cos\theta_0) = 2.86L(\cos\theta_V - \cos\theta_0) = 2.86L\frac{C_{eq}V^2}{2} \qquad (1)$$

The experimental results involving droplet transport on triangular coplanar electrodes clearly demonstrate an increase in the actuation force (by a factor of 2.86). Additionally, simulation of the electric field reveals that the electric charge density is more towards the corner of the triangular electrodes, thus generating higher electrocapillary force on the droplet towards the corner of the activated electrode. This results in the preferred movement of the droplet towards the corner of the activated electrode, thereby providing a zigzag path for the droplet, and may be beneficial for droplet mixing, splitting and other lab-on-a-chip applications.



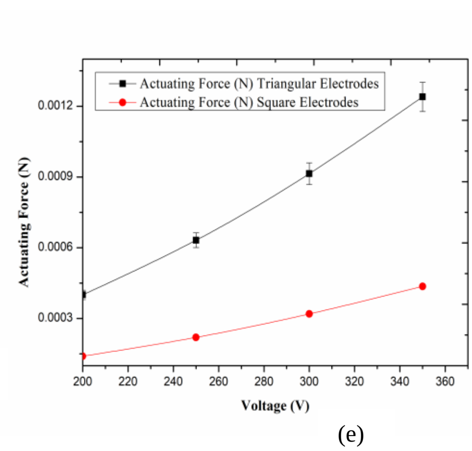


Figure: (a) fabricated triangular coplanar electrodes (1.5 mm); (b) fabricated square coplanar electrodes (1.5 mm); (c) electric field distribution of triangular electrodes; (d) electric field distribution of square electrodes; (e) comparison of actuating force in triangular and square coplanar electrodes.

References:

[1] Jean Berthier , Philippe Dubois, Philippe Clementz, Patricia Claustre, Christine Peponnet, Yves Fouillet, Sensors and Actuators A **134** ,471–479. (2007).